65th CONGRESS, 2d Session. } SENATE. { DOCUMENT No. 270.

PHOSPHATE ROCK IN THE MANUFACTURE OF FERTILIZERS.

LETTER

FROM

THE SECRETARY OF AGRICULTURE,

TRANSMITTING,

IN RESPONSE TO SENATE RESOLUTION OF JULY 5, 1918, CERTAIN INFORMATION RELATING TO PHOSPHATE ROCK AVAILABLE FOR USE IN THE MANUFACTURE OF FERTILIZERS, TOGETHER WITH LOCATION OF BEDS OR DEPOSITS, QUANTITY MINED IN THE UNITED STATES AND HOW UTILIZED, EXPERIMENTS THAT HAVE BEEN MADE BY THE DEPARTMENTS AS TO THE USE OF PHOSPHATE ROCK, INCLUDING INFORMATION AS TO THE LEGISLATION NECESSARY TO MAKE AVAILABLE THESE DEPOSITS OF SUCH ROCK ON THE PUBLIC DOMAIN.

AUGUST 1, 1918.—Referred to the Committee on Agriculture and Forestry and ordered to be printed.

DEPARTMENT OF AGRICULTURE,
Washington, July 20, 1918.

The VICE PRESIDENT,
United States Senate.

SIR: In compliance with Senate resolution No. 274, I have the honor to transmit herewith a memorandum from the Chief of the Bureau of Soils setting forth the information available in the department concerning phosphate rock, as follows:

(1) The location of the beds or deposits found in the several States, and probable extent and grade of these deposits;

(2) The quantity of phosphate rock mined and used in the United States and that annually exported and the average or ordinary cost of the same per ton;

(3) The quantity or portion of the entire phosphate rock mined in the United States that is used in the manufacture of commercial fertilizers and that which is used for fertilizing purposes in the raw state;

(4) What experiments have been conducted by the Department of Agriculture and the State experiment stations on the use of raw ground phosphate rock as a fertilizer, the various crops to which it has been applied, and the results of those experiments;

(5) The value and necessity of phosphorus for the production of the grain, vegetable, and cotton crops commonly produced in the United States; and

(6) The legislation necessary to make available the deposits of phosphate rock on the public domain.

As stated in the memorandum, the bill S. 2812, which is now pending in conference, will, if enacted into law, facilitate the development of the western phosphate deposits. Unfortunately this measure, as amended by the House without this department having had an opportunity to submit a report to the Public Lands Committee, contains a defect which would very seriously affect the administration and integrity of the national forests by specifically providing that coal lands in the national forests shall be subject to entry and purchase and by failing to provide for protection of national forest interests. I have written to the conferees calling their attention to the importance and necessity of amending this bill so that reserve lands will be subject only to the leasing provisions of the bill and not to purchase and patent.

Very respectfully,

D. F. HOUSTON,
Secretary.

[Memorandum regarding Senate resolution No. 274 calling upon the Secretary of Agriculture for information concerning phosphate rock and its use in the manufacture of fertilizers.]

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., July 20, 1918.

1. The United States possesses greater resources of phosphate rock than any other nation. These deposits occur in various sections of the country and at many different geological horizons ranging from the Carboniferous to the late Tertiary periods. Named in the order of their present commercial importance, these deposits are as follows: The phosphates of Florida, which comprise two types, namely, the hard rock and the pebble phosphate; the phosphates of Tennessee, which are of three types, namely, brown, blue, and white rock; the nodular phosphates of South Carolina; the enormous deposits of phosphate rock in the western States of Utah, Idaho, Wyoming, and Montana; the brown phosphate of Kentucky; and the phosphate deposits of Arkansas.

Several years ago the Bureau of Soils undertook to collect data showing the reserve supplies of phosphate rock in the various deposits of this country. The results of this investigation are given below in Table I:

TABLE I.—*Reserve supply of phosphate rock in the United States.*

	Tons.
Utah, Idaho, Wyoming, and Montana:	
High-grade rock	2,500,000,000
High grade equivalent of all grades	7,500,000,000

	Tons.
Florida:	
High grade	354, 300, 000
High grade equivalent of wash heaps	20, 000, 000
South Carolina: High grade equivalent of all grades	10, 000, 000
Arkansas: High grade equivalent of all grades	20, 000, 000
Kentucky: High grade equivalent of all grades	500, 000
Total	10, 519, 875, 000

It must be understood that the above figures include a great deal of low-grade material, the recovery of which has not been found commercially practicable.

FLORIDA PHOSPHATES.

Hard rock.—The Florida hard-rock regions lie toward the west coast of the Florida Peninsula and extend from Suwanee and Columbia Counties southward to Citrus and Hernando Counties, a distance of over 100 miles. The mines are reached by two railroads and have easy access to the seaports on both the east and west coasts. In general the phosphate is a cream-colored hard rock containing an average of 77 per cent tricalcium phosphate (bone phosphate of lime) and less than 3 per cent iron and aluminum oxides. Up to the time of the war practically the entire annual output of these fields was shipped abroad. Owing to the pockety nature of the hard-rock deposits the material is expensive to mine, hence has not been as extensively exploited since the discovery of the more cheaply mined pebble deposits. The life of the hard-rock fields, however, is regarded as rather limited.

Pebble phosphate.—The pebble-phosphate area of Florida lies to the south of the hard-rock regions in Polk and Hillsborough Counties. The mines are reached by three railroads, which haul much of the rock to the ports on the western coast of Florida, where part of it is shipped abroad and part to the fertilizer factories along the Atlantic seaboard. Florida pebble rock is the most extensively mined phosphate in the world. The phosphate as a whole consists of medium-sized light-gray pebbles, containing on the average about 68 per cent tricalcium phosphate and less than 4 per cent of iron and aluminum oxides. Up to the time of the war the consumption of pebble phosphate was about equally divided between this country and Europe. Many regard the Florida pebble deposits as practically inexhaustible. Certainly their end is not in sight.

TENNESSEE PHOSPHATE.

Brown rock.—The brown-rock phosphate of Tennessee occurs in the central part of the State, extending in a general north and south direction from the northern to the southern boundary lines. The deposits are reached by three railroads, and the mines in Davidson County have easy access to the Cumberland River. The rock is of Ordovician age, and in general consists of beds of brown porous plates of varying thickness resting upon a phosphatic limestone. As separated by mechanical means the phosphate contains an average of 72 per cent tricalcium phosphate and 5 per cent iron and aluminum oxides. Practically all of this phosphate is now consumed in this country. The life of the brown-rock fields is thought to be rather limited.

Blue rock.—The important deposits of blue-rock or Devonian phosphate in Tennessee occur in Maury, Hickman, and Lewis Counties, and are reached by three railroads. The rock as a whole is grayish blue or black in color, and occurs in beds from 1 to 4 feet in thickness. The average grade is about 72 per cent tricalcium phosphate. Blue rock is being exploited to a rather limited extent, but there are enormous tonnages still to be mined.

White rock.—The white phosphates of Tennessee occur on both sides of the Tennessee River in Perry and Decatur Counties. Those in the latter county are within fairly easy access of a railroad, but those in Perry County have to be transported by wagons to the river, a distance of about 6 miles.

Owing to their pockety nature and the rather poor transportation facilities these deposits have not been exploited to any great extent. The supply also appears to be rather limited.

SOUTH CAROLINA PHOSPHATE.

The phosphate area of South Carolina lies along the coast in a belt which in places is fully 20 miles wide, extending from the Wando River, in Charleston County, to the Broad River, in Beaufort County. The area has excellent transportation facilities by both land and water. The rock as a whole consists of gray nodules of medium hardness with an average grade of 61 per cent tricalcium phosphate. Since the discovery of the higher grade phosphates of Florida and Tennessee the production of South Carolina rock has fallen off considerably. The deposits, however, are estimated to contain approximately 10,000,000 more tons of marketable rock.

THE WESTERN PHOSPHATES.

The western phosphate fields are located in southeastern Idaho, southwestern Wyoming, northern Utah, and western Montana. Some of the better deposits are within fairly easy access of the railroads, but the material must be hauled over a thousand miles in order to find even a limited market.

The rock is of Carboniferous age, and occurs in beds from 2 to 6 feet in thickness overlain by limestone and phosphatic shales. It ranges in color from gray to black and has an average content of 70 per cent tricalcium phosphate.

The western deposits have been exploited to a very limited extent, and they contain a reserve supply of phosphate variously estimated at from 5,000,000,000 to 10,000,000,000 tons.

KENTUCKY PHOSPHATE.

Small deposits of phosphate rock resembling the brown rock of Tennessee have been found in Woodford, Lexington, Fayette, Scott, and Jessamine Counties, Ky.

The most important deposits have been found in Woodford County, where they have excellent transportation facilities. The rock ranges in grade from 60 to 75 per cent tricalcium phosphate. It has been developed so far in only the one locality (Woodford County), but there is evidence of a considerable tonnage, which will no doubt prove a valuable source of phosphatic fertilizer.

ARKANSAS PHOSPHATE.

The phosphates of Arkansas occur in the northern part of the State in Independence County about 12 miles from Batesville. The best rock is dark brown in color and has an average content of 55 per cent tricalcium phosphate. Mining operations have ceased in the Arkansas fields, since it has been found more economical to supply the demand for phosphatic fertilizers just west of the Mississippi River from the higher grade deposits of Tennessee. It is estimated, however, that these deposits contain approximately 20,000,000 tons of phosphate rock.

2. In 1917 the production of phosphate rock in the United States amounted to 2,610,743 tons. There were, however, 2,653,829 tons actually marketed, as against a marketed output in 1916 of 2,081,467. The last year, therefore, showed a gain of 572,362. Prior to the world-wide war the amount of phosphate exported from this country was approximately equal to that consumed in the United States, but owing to the high freight rates and the closing of certain foreign ports the exportation has been very materially reduced. In 1917, as far as can be ascertained at present, only 33,999 tons of phosphate were exported, while the remaining 2,633,829 were consumed for domestic use. The cost of this rock varied from $2.60 to $5 per ton f. o. b. mines, depending on the grade of the rock, labor conditions, accessibility of the deposits, and other factors influencing the cost of mining operations. The production, exports, and domestic consumption of phosphate rock for the last five years are given in Tables II and III:

TABLE II.—*Production of phosphate rock in the United States.*

[In tons of 2,240 pounds.]

Phosphate.	1913		1914	
	Tons.	Value.	Tons.	Value.
Florida hard rock	510,811	$3,371,386	[1] 309,689	$1,912,197
Florida land pebble	2,043,403	6,334,549	1,829,202	5,442,547
Total, Florida	2,554,214	9,705,935	2,138,891	7,354,744
South Carolina land rock	109,333	440,588	156,363	496,907
Tennessee	439,822	1,649,303	451,942	1,694,782
Other States	5,050	18,167	5,775	17,323
Total, United States	3,108,419	11,813,993	2,752,971	9,643,756

Phosphate.	1915		1916		1917	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Florida hard rock	42,962	$231,995	81,071	$432,919	93,339	$457,881
Florida land pebble	1,368,282	4,186,943	1,601,061	4,739,141	2,016,462	5,242,801
Total, Florida	1,411,244	4,418,938	1,682,132	5,172,060	2,109,801	5,700,682
South Carolina land rock	78,543	329,902	39,035	147,552	45,541	188,358
Tennessee	383,833	1,063,217	454,515	1,363,545	439,022	1,819,307
Other States	.....	.....	1,610	10,797	16,379	45,304
Total, United States	1,873,625	5,812,057	2,177,292	6,693,954	2,610,743	7,753,651

[1] Reported by the United States Geological Survey.

TABLE III.—*Statistics of phosphates in the United States.*

[In tons of 2,240 pounds.]

Year.	Production.	Imports.	Exports.[1]	Consumption.
1913	3,062,975	26,408	1,338,450	1,724,525
1914	2,752,971	15,078	928,992	1,839,057
1915	1,873,625	5,359	253,549	1,625,435
1916	2,177,292	4,612	203,659	2,081,467
1917	2,610,743	.....	133,909	2,633,829

[1] Neglecting the insignificant exports of foreign products.

3. With the exception of a relatively small tonnage used in the manufacture of phosphorus, practically all of the phosphate rock produced in this country is used for agricultural purposes. This means that at least 2,500,000 tons of phosphate rock were used in fertilizers in 1917. Most commercial mixed fertilizers have for their basis acid phosphate, which is produced by the action of sulphuric acid upon phosphate rock. This treatment changes the phosphoric acid contained in this mineral into a water-soluble form which is readily available to growing crops. During the past decade, however, the use of finely ground raw phosphate rock for direct application to the field has been experimented with in several States. The consumption of this material in 1917 is estimated to have exceeded 90,000 tons, as against 65,673 tons in 1916. This increase is due largely to the high price of acid phosphate, caused by the use of sulphuric acid in the production of munitions of war. The average price of finely ground phosphate rock in 1917 was approximately $6.50 per ton.

4. Numerous field, pot, and laboratory experiments have been conducted by the State experiment stations throughout the country with a view to determining the value of raw rock phosphate as a fertilizer. It has been applied to practically all the staple crops grown in the Southern, Middle Western, and Eastern States. The manner in which these experiments have been conducted has varied greatly, and therefore it has been found practically impossible to reduce the results to a common basis for the sake of comparison. The Bureau of Soils, after a careful study of the 232 field experiments recorded in the experiment-station literature, as well as the numerous pot and laboratory tests, has prepared a bulletin on this subject which describes in detail the more important long-time experiments. The conclusions reached in this report are that raw-rock phosphate, when very finely ground and applied liberally, will increase materially the yield of most crops grown on many different soil types, and that the presence of decaying organic matter appears to increase the effectiveness of this phosphatic fertilizer. The data, however, do not allow of a fair comparison between finely ground raw rock and the soluble acid phosphate used in commercial fertilizers. This technical bulletin is now in press. A copy of a recently published technical article on the same subject, however, is attached hereto.

5. Phosphorus is an essential constituent of living protoplasms, and hence an adequate supply of this element is indispensable for the growth and development of all plants. Experience has shown

that on many agricultural soils applications of suitable forms of phosphatic fertilizers usually give increased crop yields and frequently also an improvement in quality of product. Phosphoric acid, therefore, is a necessary and important constituent of all so-called complete fertilizers.

A certain quantity of phosphoric acid must be present in the soil for the proper growth and development of all plants. In relatively liberal quantities its more important effects on plant life are as follows: (1) It aids rapid growth and development of the young plant, particularly as regards the root system; (2) it distinctly favors early maturity; (3) in general, it increases the proportion of the fruiting or reproductive to the purely vegetative portions of the plant, and hence favors increased proportions of grain as compared with straw in the cereals, tubers as compared with vines in potatoes, fiber and seed as compared with stalk in the cotton crop, and similarly affects other crop plants.

6. While the quantity of phosphate rock under the control of private owners is amply sufficient to meet all the present requirements of this country for phosphatic fertilizers, the time is not far distant when it will be important if not absolutely essential to utilize the deposits of phosphate rock now on the public domain. A bill (S. 2812) providing for the leasing of such lands on the payment of a reasonable royalty to the Government is now in the hands of the conferees. The measure, if enacted, should result in opening up the phosphate deposits in the West.

MILTON WHITNEY,
Chief of Bureau.

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